Environmental Development xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Environmental Development

journal homepage: www.elsevier.com/locate/envdev

Climate change and the aviation sector: A focus on the Victoria Falls tourism route

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ARTICLE INFO

Keywords:
CORSIA
Victoria falls
Green aviation
Tourism
Carbon reduction
Climate change

ABSTRACT

This study examined the environmental impacts of the aviation industry on the Victoria Falls tourism route and sustainability measures being put in place to deal with aviation's impact on climate change. Primary data that includes an online survey of 370 tourists and secondary data from IATA Schedule Reference Analyzer among other sources were used in establishing the carbon footprint of the sector and an assessment of measures being undertaken to cut back on greenhouse gas (GHG) emissions in this case study. The study revealed that there is a correlation between the aviation industry and climate change. Despite efforts to cut back on carbon emissions, such efforts are not sufficient to result in meaningful cutbacks in GHG emissions owing to the inadequate regulatory framework and capacity challenges. Currently, the tourism sector on the Victoria Falls route outpaces technological gains aimed at achieving carbon-neutral growth. It is in African aviation's best interests to cut back on carbon emissions, which can be done through public and private partnerships by taking advantage of available research. In such efforts, transparency and accountability will assist in steering the aviation industry towards the green path. Further research is recommended on how Africa can tap into alternative aviation fuels as a measure of achieving sustainable development goals.

1. Introduction

The increased burden and threat of climate change have given rise to a global audit of all sources of carbon emissions as the quest for a sustainable climate solution grows. One of the sectors that have come under intense environmental scrutiny is the aviation industry, which has been critiqued of being environmentally unsustainable in an era where sustainability is crucial (Dube et al., 2018; Clarke and Chagas, 2009). There is also evidence that the aviation industry is the most significant contributor to the tourism industry's increasing impact on environmental unsustainability (Peeters et al., 2006). This resulted in an outcry from some environmentalists after the aviation industry was left out of the Paris Agreement on climate change of 2015 as many felt that its carbon footprint was too significant to be left to self-regulate under Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) (Scott et al., 2016b).

Peeters et al. (2016) argue that, despite the global desire for emission reductions, the aviation industry's greenhouse gas (GHG) emission is expected to continue growing, contrary to industry claims of carbon-neutral growth by 2035. This is against the background of aviation growth demands, which are set to outpace promised technological benefits of cleaner and more fuel-efficient aviation (Peeters et al., 2016). Several studies show no evidence that tourists are eager to sacrifice their travel patterns for climate

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https://doi.org/10.1016/j.envdev.2018.12.006
Received 16 May 2018; Received in revised form 7 December 2018; Accepted 14 December 2018
2211-4645/

change expedience (Kantenbacher et al., 2018), as pro-environmental attitudes were found to be too weak among individual air travellers to warrant GHG reductions.

The aviation and the tourism industries together account for more than 5% of global carbon emissions, with the aviation industry accounting for about 3% of that total (Schäfer and Waitz, 2014). However, due to untamed growth in GHG emissions, the tourism industry is projected to account for 40% of global carbon emissions by 2050 (Dubois and Ceron, 2006). Dessens et al. (2014), noted that the aviation industry adversely affects climate as it produces GHGs such as water vapour, nitrous oxides, methane and the contrail effect (a greenhouse effect that results from line-shaped clouds produced by jet engine emissions at cruising altitude), which adversely alter climatic patterns.

Given the forgone, this research sought to estimate the amount of carbon emissions being produced on the Victoria Falls tourism route. It further sought to assess how aviation players on this route are mitigating their carbon emissions through interventions that reduce their carbon footprint to address climate change as the quest for tackling climate change under Sustainable Development Goal (SDG 13) intensifies globally. The study is in response to knowledge gaps that exist within the aviation sector and most importantly at a regional level. The study is more critical as it coincides with ten-year celebrations post-carbon neutral commitments by the aviation sector and only a few months before the 2020 commitment of carbon-neutral growth by the aviation sector (International Air Transport Association- IATA, 2008). In 2008 the aviation industry role players signed a declaration committing to a four-pillar plan aimed at carbon reduction namely through:

- Investment in new technology (including sustainable aviation fuels)
- Continuous operational improvements
- Better use of infrastructure.
- A single global market-based measure

This study is therefore crucial more so given that it involves an evaluation of major airline flagships in Africa namely Ethiopian Airways, Kenyan Airways, South African Airway and Comair amongst other airlines which dominate the African skies. Valuable lessons can be learnt on how African aviation is dealing with climate change.

2. Materials and methods

Victoria Falls is a relatively busy tourist destination with several flights from the region and the continent plying the routes as shown in Fig. 1. The resort receives more than half a million tourists annually (Dube and Nhamo, 2018a, 2018b) with most of the flights originating from two South African flight hubs, namely the Oliver Reginald (OR) Tambo International Airport in Ekurhuleni, and Cape Town International Airport. The furthest direct flights to Victoria Falls are from Nairobi (Kenya) and Addis Ababa (Ethiopia). Other flights come from Botswana, Zambia and Namibia. In 2017 two routes were opened to Victoria Falls International Airport, and these included the Victoria Falls-Nairobi and Victoria Falls-Addis Ababa routes with one flight each per day.

In this study, a mixed methods design was used, which involved an online survey (n = 370) of tourists, observations, secondary data analysis and semi-structured expert interviews with pilots, aviation experts, civil aviation authorities, aircraft engineers and aviation meteorologists. To calculate carbon emissions, the International Air Transport Association (IATA) Schedule Reference Analyzer (SRS) was used to get traffic data on the Victoria Falls tourism corridor. Data for public airlines flying directly into the area were collected for analysis as it was found to be the most convenient thing to do. Interviews solicited information on the impact of climate change on aviation, mitigation actions, and the operational mechanisms of flying under various climatic conditions. Secondary data analysis involved a review of air traffic schedules, the IATA reports, civil aviation reports, and aviation company sustainability and financial reports.

A schedule of airlines that ply the Victoria Falls International Airport, the Kasane International Airport, and the Livingstone Airport was obtained from IATA SRS after which the estimated carbon emissions for each route were calculated using web-based International Civil Aviation Organization (ICAO) Carbon Emissions Calculator Version 9. The ICAO recommends the use of this calculator as it captures and gives average estimates of each route based on the type of flight, number of passengers, distance, fuel consumption for that route, and other flight parameters that might be difficult to capture on a flight-specific scenario. According to Baumeister (2017), this method has been endorsed as the principal scientific method for use in aviation emission calculation. Fig. 2 highlights the procedure that is taken in calculating the carbon footprint for each airline.

From Fig. 2, the following abbreviations need further explanations for completeness. The Great Circle Distance (GCD) is the distance between two airports, which is calculated from the latitude and longitude coordinates obtained from the ICAO location indicators database. Fuel/km represents fuel used per kilometre. The AMSD stands for Airlines Multilateral Schedules Database, while CO_2 means carbon dioxide. Y-seats refers to the number of economy class seats that one can fit inside the equivalent aircraft.

The ICAO and IATA recommend the use of guidance provided by the Quality Assurance Standard (QAS) to determine the carbon equivalent and radiative forcing. The QAS is mandated by these two organisations to audit the calculation entry of carbon emissions and offsetting data (IATA, 2015). The QAS (2016) recommended the use of the United States Environmental Protection Agency (EPA) calculator in calculating the amount of carbon dioxide equivalent and desired offsetting projects. The EPA's Greenhouse Gas Equivalencies Calculator was therefore used in the calculation of the carbon equivalent and offsets standard in line with aviation regulatory standards.

Fig. 1. Victoria Falls aviation servicing routes (routes not to scale).
Source: Authors (2018)

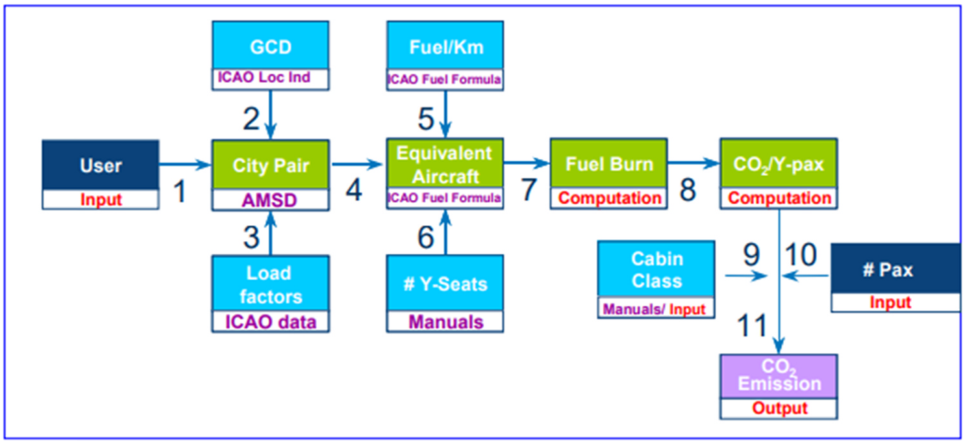

Fig. 2. ICAO carbon calculation procedure.
Source: (IATA, 2015b:4) *GCD (Great Circle Distance): the distance between airports, which is calculated from the latitude and longitude co-ordinates obtained from the ICAO location indicators database.

3. Results

Fig. 3 shows that most tourists access the Victoria Falls by air, with a significant number using road transport. Respondents also reported extensive use of private transport in their repeated visits to the Victoria Falls. Just less than two-thirds (66%) of the tourists

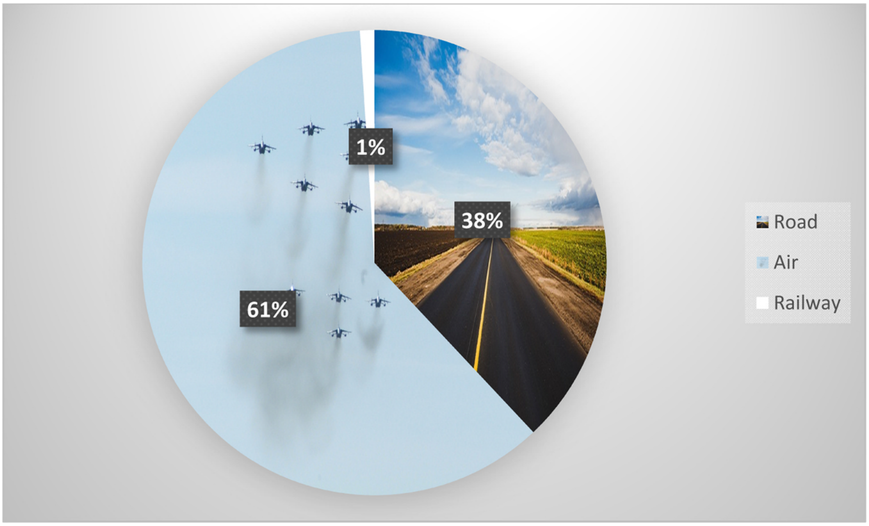

Fig. 3. Mode of transport used by tourists to visit Victoria Falls (n = 370).
Source: Fieldwork (2017)

travelled to the resort using private transport. Whether tourists use public or private transport has a direct bearing on the level of the carbon footprint for their tour.

It emerged that the development and upgrading of the Victoria Falls International Airport (VFA) have facilitated the growth of the travel and tourism industry and, consequently, growth in GHG emissions. This emanates from the growth of both human and vehicular (air and road) traffic into and out of the resort town. The commissioning of the upgraded VFA to accommodate larger aircraft and more airlines has seen an influx of new airline operators. As of July 2017, four airlines had commissioned flights to the VFA – almost doubling the air traffic at the airport. Out of the four airlines, two offer the long-haul flights from Nairobi and Addis Ababa. Several other charter flights fly to the VFA daily. What also emerged was that the Victoria Falls resort town is near two other international airports located within a 100 km radius. These are the Kasane International Airport (Botswana) and the Livingstone International Airport (Zambia). To this end, the Victoria Falls resort is fast becoming a regional tourism hub for southern Africa outside of Cape Town.

Table 1
Average carbon emissions estimates for selected major tourist destinations using the ICAO calculator.
Source: Fieldwork (2017)

Departure airport	Type of aircraft	Distance in km	Aircraft Fuel Burn/leg (kg)	Passenger CO2/Pax/ journey kg) Economy	Passenger CO2/Pax/ journey (kg) Premium
Victoria Falls international airport					
Addis Ababa (Ethiopia)	Boeing 737–700	6 650	11 660.2	563.6	1 127.4
Johannesburg (South Africa)	Boeing 737–400; Airbus A320 (320); Airbus A330–200 (332)	1 854.0	14 298.5	220.6	220.6
Cape Town (South Africa)	Embraer EMB 190; Embraer EJ135	3 808	8 915	636.0	636.0
Harare (Zimbabwe)	320, 737, ER4	1 108	6 318.6	88.0	118.1
Bulawayo (Zimbabwe)	320, 737	724.0	5 333.0	114.8	114.8
Nairobi (Kenya)	Embraer EMB 190 / EMB 195 (E90)	4 442.0	13 695.2	571	571.0
Windhoek (Namibia)	ER3 (Embraer ERJ 135)	1 996	4 602.6	469.2	508.6
Livingstone international airport					
Johannesburg (South Africa)	Boeing 737–800 (738); Boeing 737–400); Airbus A320	1 912	9 959.8	275.4	275.4
Cape Town (South Africa)	Embraer E90	3 862	12 378.6	476.2	476.2
Nelspruit (South Africa)	Embraer ERJ 145 (ER4)	1 998	5 072.4	446.8	446.8
Nairobi (Kenya)	Embraer EMB 190 / EMB 195 (E90)	4 394	13 586.8	522.8	522.8
Lusaka (Zambia)	BAE Jetstream 41 (J41)	788	1 129.0	124.6	124.6
Kasane international airport					
Johannesburg (South Africa)	Avro RJ85 Avroliner (AR8)	1 954	8 662.4	316.0	316.0
Maun (Botswana)	ATR 72 (AT7)	598	1 327.0	67.2	67.2
Gaborone (Botswana)	Embraer ERJ 145 (ER4)	1504	2 056.2	142.8	142.8

Table 2
Approximated carbon emissions for airlines flying into Victoria Falls tourism corridor Emissions per week = ***Leg fuel burn*** × ***the number of flights*** (***legs***/***week***) Annual emissions = ***fuel burn per week*** × ***3. 15*** (***constant***)***x52*** (***weeks in a year***) (IATA, 2015).

			Victoria Falls international airport (VFA)	
Departing airport	**Name of flight**	**Flights/Week**	**Estimated fuel burn kg/ week**	**CO_2e kg /year**
O R Tambo	British Airways 6285	7	99,701.00	16,382,868.32
O R Tambo	British Airways 6283	3	3481.00	571,997.92
O R Tambo	South African Airways	7	99,701.00	16,382,868.32
O R Tambo	Air Zimbabwe	2	28,486.00	4,680,819.52
O R Tambo	Fast Jet	3	3481.00	571,997.92
Nairobi	Kenyan Airways	2	27,390.00	4,500,724.80
Addis Ababa	Ethiopian Airways	4	46,640.80	7,664,016.26
Harare	Air Zimbabwe 322	6	37,914.00	6,230,028.48
Harare	Fly Africa Zimbabwe 162	4	25,276.00	4,153,352.32
Harare	Fast Jet 8001	7	44,233.00	7,268,366.56
Harare	Fast Jet 8003	2	12,638.00	2,076,676.16
Bulawayo	Air Zimbabwe 326	1	5333.00	876,318.56
Bulawayo	Fly Africa Zimbabwe 191	4	20,932.00	3,439,546.24
Windhoek	Air Namibia 405	4	53,490.00	8,789,476.80
Cape Town	Kenyan Airways 793	3	26,745.00	4,394,738.40
Cape Town	South African Airways 8690	6	18,412.00	3,025,459.84
Total VFA airport	**Total airport**		**553,853.80**	**91,009,256.00**
			Livingstone international airport	
O R Tambo	British Airways 6291	7	69,720.00	11,456,390.40
O R Tambo	South African Airways 48	7	69,720.00	11,456,390.40
Nelspruit	South African Airways 8870	7	35,504.00	5,834,017.28
Nairobi	Kenya Airways 782	3	41,625.00	6,839,820.00
Livingstone	Proflight Zambia 704	4	4516.00	742,069.12
Livingstone	Proflight Zambia 700,702,706	5	5645.00	927,586.40
Livingstone	Proflight Zambia 708	7	7903.00	1,298,620.96
Grand Total	**Total airport**		**234,633.00**	**38,554,894.56**
			Kasane international airport	
O R Tambo	South African Airways 8306	7	62,034.00	10,193,426.88
Maun	Air Botswana 34	2	2654.00	436,105.28
Gaberone	Air Botswana 26,24	3	6168.00	1,013,525.76
Airport total	**Total airport**		**70,856.00**	**11,643,057.92**
	Total all airports			**141,207,208.48**

Table 1 outlines carbon emissions estimates for flights to the Victoria Falls region. Furthermore, of the three airports as observed in Table 2, VFA has the largest share of the carbon footprint given the high traffic volume that goes there.

Total carbon emissions for flights to the Victoria Falls International Airport annually equates to about 92,009,256 CO_2e kg per year, while Kasane International Airport and Livingstone International Airport produce 11,643,057.92 CO_2e kg and 38,554,894,56 CO_2e kg respectively.

Table 3 summarises most common initiatives that are in place to deal with GHG emissions on the Victoria Falls route. However, in the course of the research, it emerged that there are only a few airlines that are transparent regarding how they deal with carbon emissions, with most parastatal and low-cost airlines seemingly operating in the shadows. Carbon reduction appears to be the least of most airlines' worries, with some failing to publish the mandatory annual financial reports due to viability and management challenges.

Some airlines are taking initiatives to address their Scope 1, 2 and 3 emissions. Scope 1 emissions are direct GHG emissions within the organization's boundaries, in this case, mobile fuel from company-owned aircraft and vehicles (World Resources Institute - WRI, 2009). Scope 2 emissions emanate from electricity and Scope 3 entails other indirect GHG emissions. The following subsections deal with initiatives to reduce carbon on a Scope-by-Scope basis, starting with Scope 1.

Regarding Scope 1 emissions reduction initiatives, 2016 annual reports for SA Airlink and South African Airways (SAA) indicate that both SA Airlink and SAA had effected the Continuous Descent Approach (CDA) resulting in reduced fuel burn. CDA is a procedure in which arriving descends from an optimal position in a manner that reduces thrust and also avoids level flight. The technique reduces both noise and fuel consumption on landing. Through this initiative, the two airlines managed to reduce fuel burn on approach to landing, saving about 37 km worth of fuel on approaching the airport. Also, at least 18 km worth of fuel is saved during take-off through the same initiative with each trip. A reduction in fuel burn means a reduction in carbon emissions. Furthermore, SA Airlink initiated a single-engine taxi programme.

Based on its 2017 annual report, it emerged that Comair initiated a raft of measures to reduce its Scope 1, 2 and 3 emissions. These included the use of fixed ground power units rather than the old method of using auxiliary power units, paperless cockpits, reduction in the potable water on board, use of borehole water, and lessening the number of aircraft galleys to reduce weight on board. Besides implementing CDA, which led to a 1.4% emission decrease on its entire fleet, Comair went further and retrofitted its

Table 3
Carbon emission offsetting initiatives by various airlines.
Source: Fieldwork (2017)

Airline	Emission reduction targets set	Audit per scope (1, 2 & 3)	Reducing fossil dependency	Energy & water saving/ efficiency initiatives	Waste minimisation and recycling initiatives	Carbon offsetting initiatives	Fleet modernisation and operational efficiency initiatives
South African Airways	√	√	√	√	√	√	√
SA Airlink	√	√		√	√	√	√
Comair	√	√	√	√	√	√	√
Fast Jet Africa	–	–	–	–	–	–	–
Air Zimbabwe	–	–	–	–	–	–	–
Ethiopian Airways	–	–	–	–	–	√	√
Kenya Airways	√	–	√	√	–	√	√
Air Namibia	√	–	–	√	√	√	√

Table 4
Kenya Airways carbon reduction initiatives.
Source: Adapted from Kenya Civil Aviation Authority (2015:21)

Flight dispatch	Flight operations	Maintenance and engineering	Ground operations and commercial
o Optimising cost index o Flight plan optimisation o Alternate selection /No Alternate to Instrument Flight Rules (Adherence to flight plan) o Contingency fuel reduction from 5% to 3% o Reduction of pilot/ dispatcher additional fuel o Zero fuel weight accuracy o Mission management	o Auxiliary Power Unit (APU) utilisation o Optimised taxi fuel o Engine out taxi o Reduced flap take-off o Reduced acceleration altitude o Low noise low drag approaches o Continuous descent approaches o Reduced flap landing o Idle reverse on landing o Pilot technique and flight management	o Weight reduction o Moisture insulation blankets, fly away kit o Onboard weight: dirt, dust, over paint o Drag reduction through the rigging of aircraft panels, doors and seals o Paint and cleanliness o Engine improvement o Engine care wash, engine build fuel efficiency	o Onboard weight reduction: catering carts, and galley equipment, duty-free carts, cargo containers and pallets, magazines and newspapers

B737–800 with Scimitar split winglets. This led to its older generation fleet reducing emissions by 2% during the 2016 financial period. The addition and purchase of new B737–800 aircraft – with the capacity to carry 21 more passengers and a reduction of 200 *l* per hour less fuel than its old B737-400 aircraft – led to a reduction in carbon emissions per journey. Since the 2011 base year, the company has managed to keep its emission growth in check at 2%, while recording an aviation footprint per passenger intensity reduction of 14%.

According to the Kenya Civil Aviation Authority (2015), Kenya Airways adopted a range of measures to reduce carbon emissions from its operational activities in line with IATA principles. At least 43% of carbon reductions were from its flight dispatch, 33% from flight operations, and 14% from maintenance and engineering, with the remaining 10% being accounted for through its ground operation and commercial activities. Table 4 outlines the various activities and initiatives that have been taken to reduce the carbon emissions in the areas identified above. Regarding efforts to reduce carbon emissions from the aviation sector, Kenya Airways seems to be leading with regard to what they are doing with the assistance of the ICAO-EU Assistance Project on Capacity Building for CO_2 Mitigation from International Aviation. The combined effort of civil society and the government seems to pay dividends in this regard.

Air Namibia understands that its operations have a detrimental effect on the environment. In a bid to align its operations with Namibia's Policy on National Climate Change (Government of Namibia, 2011), the airline adopted measures to reduce its operational carbon footprint. It drew many lessons from guidelines given by ICAO and implemented some measures to reduce its carbon footprint. Table 5 highlights some of the strategies and activities that have been adopted by the airline with the backing of the Directorate of Civil Aviation in Namibia. The measures can be categorised into three broad areas, namely (1) improved air traffic management (ATM) and infrastructure use, (2) more efficient operations, and (3) monitoring and data resources. In 2016 the airline sought to cut its emissions by 101,667 kg of fuel within a year.

Three airline companies, namely SA Airlink, SAA, and Comair, indicated that they were making frantic efforts to deal with Scope 2 and Scope 3 emissions (Comair, 2017; SA Express, 2016; SAA, 2016). The companies indicated that they were involved in waste minimisation and recycling, and implemented water saving measures such as rescheduling their garden irrigation in order to reduce their direct and indirect emissions. However, there was an indication that they were having problems in recycling some of the waste from aircraft due to the restrictive legislative framework.

Comair, in a bid to reduce its carbon footprint, had embarked on the use of liquid petroleum gas for catering purposes, marshalled the use of light emitting diode (LED) lights, and made use of borehole water wherever possible. The three airlines also indicated that they had taken steps to change the light bulbs and lighting to achieve a more energy-efficient lighting system. Borehole water was reportedly used wherever possible. In Kenya, the Kenya Airports Authority was making frantic efforts to introduce the use of sustainable fuels in vehicles that are used at the airport as a carbon reduction measure.

In their reporting, Comair, SA Airlink, SAA, Kenya Airways and Ethiopian Airways noted that they have a facility that complies with IATA. Such a facility is where passengers are encouraged, when making online bookings, to donate funds to offset their carbon footprint for the journey. Various airlines offered various programmes aimed at protecting the environment, although there was no evidence of how these monies were reported in financial reports or how such funds were used.

SAA and its franchise, SA Airlink, are involved in projects that provide solar geysers for heating water in rural communities, reducing energy demand on the grid and switching to green energy. In partnership with other organisations, SAA had embarked on the utilisation of the Solaris strain of tobacco to produce sustainable fuels. The project had many benefits from empowering the local farmers in skills development, and also economically empowered the community and provided cleaner fuel. Such initiatives are commendable as they address broader aspects of the green economy. Also, the company has the ambitious project of having its head office running 100% on green energy.

Other offsets projects supported by carbon offsets funds from passengers included renewable energy projects, wildlife

Table 5
Air Namibia carbon emission reduction measures.
Source: Adapted from Directorate of Civil Aviation (2016)

Measure	Description of the measures being taken	Expected results / CO_2 reduced per annum
Efficient operation measures		
Weight minimisation	o Matching fuel requirements to flight plan minimum fuel requirements o Paperless cockpit through the removal of paper manuals o Use of closer arrival alternates o Making use of light material apparatus such as trolleys and cutlery on board o Reduction of onboard magazines to only 2/3 of flight population o Reducing potable water by 50% (leading to 57.9 t of CO_2)	321 t
Minimising/ delaying flaps (take-off and landing)	Pilots institute, as part of standard operating procedures, o low drag approaches o reduce flaps take-off o reduce flap landings	Not quantified
Reversers use	o Idle reverse on landing	633 t
Flying cost index	o Dynamic cost index	686.6 t
APU vs GPU usage		5 356 t
Aircraft maintenance	o Engine wash as part of maintenance o Maintain aerodynamically clean aircraft that is flush, skin repairs, and immaculate flight control surface rigging o Engine quality checks to ensure a return to original fuel mileage	Not quantified
CO_2 Mitigation measures implemented and ongoing		
Improvement of optimum flight altitudes	o Provision of optimum routing for aircraft o Track mile reduction initiative o Performance-based procedures implementation	Achieve the best fuel burn efficiency to attain optimum operating levels
Optimum routing	o Application of flight planning optimisation, both vertical and lateral	Track mile reduction is resulting in a 10 NM saving Reduction of 1, 929,097 kg of CO_2
Application of reduced acceleration altitude (flaps retraction level-off)		Not quantified
Optimised cost index	o Best cost index for operation	Optimum fuel burn efficiency
Better approach procedures	o Use of required navigation procedure (RNP) and Area Positive Control Procedures	Reduction of weather-induced diversions

conservation, and tree planting projects, which support the claim that airlines were leading in climate change action. Only SAA and SA Airlink reported they were involved in cleaner energy production. Challenges noted in this project will see the two airlines failing to meet the envisaged 2020 emission targets.

Ethiopian Airways claimed that it was running a vast tree planting initiative where it seeks to plant 7.5 million tree seedlings. However, these seedlings may not be sufficient to cover that airline's fleet size or to offset its carbon footprint.

Kenya Airways has adopted a three-fold approach in its quest to offset its carbon emissions with the aim of achieving carbon neutrality by 2020. According to the Kenya Civil Aviation Authority (KCAA, 2015), these initiatives include the following:

- Allowing passengers to participate in voluntary pay for their carbon emissions during the booking process. The funds generated from this initiative are used to rehabilitate the Kasigau Corridor, which is attempted through the Reducing Emissions from Deforestation and Forest Degradation (REDD +) project located in Voi. The Kasigau Corridor REDD + project is a private-sector-driven REDD + project that is the world's first registered REDD + project issued with Verified Carbon Units (VCU) under the Verified Carbon Standard (VCS). As such it is one of the few REDD + projects which is currently selling REDD + carbon credits on the voluntary market (Bernard and Adkins, 2014).
- Maintaining a young fleet that is fuel efficient and by retiring old aircraft. Kenya's fleet is less than five years old.
- Embarking on the afforestation project as part of their corporate social responsibility. This initiative has witnessed the growth of about 750,000 indigenous trees in Ngong Forest.

Our field observations revealed that there were a number of green initiatives during the construction and upgrading of the Victoria Falls International Airport (VFA). The VFA was designed in an energy-efficient manner that made use of natural lighting during the day. The reduction in lighting requirements is a positive step as it reduces the GHG emissions that are generated using electricity when lighting during the day or at night. It was noted that there was extensive use of local resources in the furnishings and building – a move that reduced the carbon footprint of the airport. The utilisation of local resources helps in reducing both the Scope 2 and Scope 3 emissions by minimising the transportation of materials over a long distance.

The airport is largely energy efficient as it utilises double-glazed windows, window tinting, and variable shading in a manner that allows natural lighting and ensures internal temperature control. The airport utilises LED lights, which are touted as the most energy-efficient type of lighting. The material that was used outside reflects much longwave radiation, which helps in reducing the demand for air conditioning in the hot and humid summer months that are synonymous with the area. Double-glazed windows serve a dual purpose: to reduce noise and to ensure thermal comfort, especially during the cold winter months. This further reduces the demand for electricity, as not using air conditioning in both the cold winter and the hot summer months results in energy cost savings and the associated carbon cost for the airport.

4. Discussion

The major use of airlines, representing a carbon-intensive industry, means that the carbon footprint for the Victoria Falls resort is equally significant. The impact of aviation is also likely to be significant given the eco-sensitive nature of the region. However, aviation remains the most viable mode of transport for the 370 respondents who represented over 45 different countries across the globe. The aviation industry is also blamed for contributing about two to three percent of total carbon emissions into the atmosphere globally (Becken and Mackey, 2017). The extensive use of private transport in and around the Victoria Falls resort is also worrying as this comes at a time when public transport and car sharing is encouraged to reduce GHG emissions (Chen and Kockelman, 2016).

The study established that most national and regional flights that ply the Victoria Falls route were old and therefore, not fuel efficient. This resulted in a much larger carbon footprint. Exceptions were noted for Kenyan and Ethiopian Airways, which have a modern and fuel-efficient fleet that lead to lower carbon footprints per passenger. The research thus highlighted that local and regional flights to Victoria Falls had a much more significant carbon footprint on distance ratio compared to international routes on emissions distance factor. The Johannesburg route had the most extensive carbon footprint due to: (i) the number of flights and frequency on that route and, (ii) fleet age, with the oldest aircraft being 27 years old. Long-haul flights from Nairobi and Addis Ababa seem to have a lower carbon distance ratio factor as the fleet is very young with an average aircraft age of 4.5 years.

Given that most tourists to Victoria Falls use the OR Tambo International Airport as the leading continental air hub, there are many flights that fly to the Victoria Falls from there. Consequently, flights from South Africa account for a significant percentage of the carbon footprint, standing at an approximate 72,849,947 CO_2e kg. All flights to Kasane, Livingstone, and the Victoria Falls International Airport contribute 141,207,208.48 CO_2e kg into the atmosphere annually.

Based on the USA EPA GHG equivalencies calculator, the airline industry to Victoria Falls will have to grow about 3.7 million tree seedlings for ten years to offset its emissions for each year as of 2017. The amount of carbon produced by plying the Victoria Falls route annually equates to the energy use of 9610 homes for one year. The number of trees that need to be grown to sequestrate the carbon emissions seems to be very high, and it is highly unlikely that the aviation industry will meet this target, even with the best intentions. As such, it is expected that the carbon emissions from the aviation sector for these airports will continue to grow in the foreseeable future.

Given the airline industry's contribution to global warming, airlines have been under pressure to mitigate climate change, resulting in the adoption of several initiatives under the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). ICAO was mandated by the United Nations Framework Convention on Climate Change (UNFCC) under the Paris Agreement on Climate Change (2014), to adopt carbon reduction initiatives for the aviation sector. However, it emerged from secondary data that there are various reporting standards currently being used by different airlines on the Victoria Falls route. This is contrary to industry best practice, which prescribes the use of internationally acclaimed and transparent reporting systems such as the GHG Protocol Corporate Accounting and Reporting Standard (revised edition) (hereafter called the GHG Protocol) from the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSA), published first in 2004 (WBCSD and WRI, 2004). The GHG Protocol is aligned with the Intergovernmental Panel on Climate Change (IPCC) best practice. It comprises 11 areas where businesses can focus on dealing with their GHG emissions. The areas include providing guidance on GHG accounting and reporting principles, business goals, and inventory design, tracking emissions over time, identifying and calculating GHG emissions, and verification of GHG emissions (WRI, 2011).

A further review of publicly available reports showed that only Comair and SA Airlink provide comprehensive annual reports on their operations with clear baseline figures and future forecasts of GHG. Air Namibia and Kenya Airways worked with their national civil aviation companies in developing strategies for addressing climate change. The other airlines, like SAA and Ethiopian Airways, provide a statement of intent and what they are doing but offer no concrete, publicly available, verifiable figures such as the baseline year and their total carbon equivalent amount. Only a few airlines indicated the amount of carbon being offset by their initiatives, making it difficult to verify the effectiveness of the current offsetting initiatives. Efforts to obtain data for budget airlines on the route were fruitless. The absence of emission figures in the majority of cases makes it difficult to know whether these airlines will meet their targets for carbon reduction by 2020 in line with ICAO claims confirming fears of lack of transparency on climate change by the sector raised by Scott et al. (2016a). The aviation industry in Africa is often run by parastatals, and viability is often a challenge due to poor management, over-taxation of the sector and corruption, among other challenges cited by Njoya (2016).

Notwithstanding these challenges, there is potential for the aviation sector to reduce its emission levels and become greener than it is now. Most airlines seem to have aligned their carbon offsetting initiatives with ICAO's recommendation for the adoption of a basket of measures in dealing with climate change. However, some of the projects that were reported to be used for offsetting carbon emissions were too small to make a significant contribution to carbon reduction initiatives. Investment in Sustainable Aviation Fuels (SAF), like the one SAA, embarked on, is touted to respond to most of the 17 United Nations Sustainable Development Goals (ICAO, 2017a). Included in SAF is biofuels. The biofuels reduce dependency on fossil fuels, reduce fresh water usage, can be mixed with jet fuel, and meet jet fuel technical specifications. In addition, biofuel projects could be used to claim carbon credits as part of the Clean Development Mechanism in respect of the United Nations Framework Convention on Climate Change established under the Kyoto

Protocol (ICAO, 2017b).

SAF production further offers avenues for the aviation industry to respond to the SDGs, especially, SDG 13 on climate action. Other SDGs of interest include (United Nations, 2015: 14):

- SDG 1: Ending poverty in all its forms everywhere.

- SDG 8: Promoting sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.
- SDG 10: Reducing inequality within and among countries.
- SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all
- SDG 12: Ensuring sustainable consumption and production patterns.
- SDG 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development.
- SDG 15: Protect, restore and promote biodiversity.

However, the capacity to deliver SAF globally remains low, with the industry producing approximately 15 million litres in 2016 (ICAO, 2017d). This figure represents approximately 2% of global aviation fuel demand (ICAO, 2017e). The dream of carbon-neutral growth, therefore, remains elusive and it might be practically realised only long after the 2020 and 2050 set targets. In general, the growth of SAF will require that land for agriculture be drastically increased. This will result in land clearance to pave the way for producing agricultural resulting in the production of carbon emissions that might result in some reversal of net gains of such an initiative. Higham et al. (2016) argue that addressing GHG emissions from the aviation industry is near impossible given the industry's complexities, which include the lack of alternative transport or a viable substitute for aviation. Furthermore, Kantenbacher et al. (2018) argue that the aviation sector is the most challenging to implement sustainability interventions due to a lack of sustainable alternatives for travellers.

The global air industry is expected to double the current number of passengers to about 7.8 billion passengers by 2036 (IATA, 2017a), with an ambitious target of flying one billion of those on sustainable fuels, which produce 80% fewer carbon emissions compared to conventional fuel (IATA, 2018). This makes the aviation sector's ambition of carbon-neutral growth by 2020, pronounced by International Civil Aviation Organization (ICAO) unrealistic. IATA (2017a) projects a more rapid growth of aviation in Africa than in any other region by 2036. Most African markets are expected to grow by 7.2% per annum in future.

It is important to note that some projects, although small, were found to be of the right framework with the capacity to meet the socioeconomic and environmental aspirations of countries as they address the nine pillars of a green economy as noted by Law et al. (2015). Projects such as SAA's Solaris biofuel project may result in economic development, skills transfer to the agricultural sector and environmental protection. At the same time, wildlife conservation may ensure the sustainability of the tourism industry, which is the mainstay of some economies in Africa, employing thousands of skilled and semi-skilled labourers. Economically empowered groups and individuals are better able to deal with the vagaries of climate change than poor communities.

The study also found that external support and government assistance were seen to foster more dedicated initiatives in reducing carbon emissions in the likes of Kenya Airways and Air Namibia. This cements the argument that, for a robust cut in carbon emissions, there is the need for a combined effort between the state and other role players. Development partners were seen to play a key role in leading the reduction of carbon emissions in the case of Kenya, and other countries such as Botswana are now drawing lessons from the Kenyan experience (IATA, 2017a). However, the challenge is that all the carbon offsetting projects might not assist Zimbabwe in any way, even though it bears the brunt of global warming and climate change.

While the aviation industry contributes to climate change through GHG emissions (Baumeister, 2017), the sector is equally vulnerable to the vagaries of extreme events related to climate change. Williams (2017) found that extreme rainfall events disrupted air traffic movement and destroyed airport infrastructure. Coffel and Horton (2015) observed that increases in temperature at some airports resulted in aircraft load shedding as the atmosphere gets thinner, undermining aircraft engine performance. Storer et al. (2017) postulate that an increase in the occurrence and severity of clear air turbulence (CAT) as a consequence of climate change could see an increase in injuries and damages among travelling tourists.

Lastly, to some extent, the VFA meets the provisions set by the Airports Council International for a green airport. The VFA put in place such initiatives as reduced taxiing and queuing time when an aircraft is arriving or departing. The airport further reduced taxiing distance through the intelligent configuration of the runway and wise management of arriving aircraft by providing gates as soon as an aircraft arrives to assist in reducing the waiting time and fuel burn.

5. Conclusion

The research was aimed at evaluating the linkage between the aviation industry and climate change using Victoria Falls tourism route as a case study. It emerged from the study that the aviation industry is far from achieving its much claimed carbon neutral growth by 2020, as gains in technology are largely outpaced by aviation industry growth. Aviation fleet replacement is slow and not enough to keep pace with industry growth as the African aviation fleet is, by and large, old and carbon emission intensive. From the Victoria Falls case study, it was noted that the amount of carbon emissions that are produced and the basket of measures put in place are not enough to offset the amount of carbon emissions that are being produced. The anticipation is that even though some of the offset programmes that are being undertaken respond to various developmental needs such as employment creation, environmental protection, poverty reduction and green development initiatives. It is the view of the authors that these need to be fast-tracked if they are to meet sustainability needs.

Our view is that the uptake of clean technology and aviation in Africa is replete with challenges, and it will take time before these can be addressed. Even with the best technology and newer fuel-efficient aircraft on the market, the carbon emissions from the African aviation sector are likely to balloon in the foreseeable future in line with the global trend. Such growth will exacerbate climate change, which is already causing challenges for the air traffic movement. There is thus a need to put policy measures in place that address climate change through various incentives and punitive measures. Without addressing viability issues affecting the air industry, it will be difficult for most state-owned airlines to be cleaner. The growth of budget airlines seems to occur at the expense of the environment and measures are needed to ensure green growth in aviation.

The hype surrounding alternatives in aviation fuels is unlikely to benefit Africa much due to the absence of supportive financial resources, infrastructure and technology. Retrofitting of aircraft has led to some positive gains, and there is a need to educate travellers on the need for responsible travel. However, much more work is needed in aviation research to enhance green growth, as in many cases the aviation industry continues to lack transparency and accountability. Further research is thus imperative to understand more sustainable ways of reducing the carbon emissions produced by the aviation sector in a manner that will benefit Africa to address its development needs in line with the SDGs.

Acknowledgements

The authors would want to thank EXXARO Chair for Business and Climate Change at the University of South Africa, Pretoria, South Africa for funding the field work.

References

Baumeister, S., 2017. Each flight is different': carbon emissions of selected flights in three geographical markets. Transp. Res. Part D Transp. Environ. 57, 1–9.

Becken, S., Mackey, B., 2017. What role for offsetting aviation greenhouse gas emissions in a deep-cut carbon world? J. Air Transp. Manag. 63, 71–83.

Bernard, F., Adkins, B., 2014. Implementing REDD+: Lessons from Kasigau Corridor project in Kenya. ASB Policy Brief No. 44, ASB Partnership for the Tropical Forest Margins, Nairobi, Kenya.

Chen, T.D., Kockelman, K.M., 2016. Carsharing's life-cycle impacts on energy use and greenhouse gas emissions. Transp. Res. Part D Transp. Environ. 47, 276–284.

Clarke, C., Chagas, T., 2009. Aviation and climate change regulation. In: Freestone, D., Streck, C. (Eds.), Legal Aspects of Carbon Trading: Kyoto, Copenhagen, and Beyond. Oxford University Press, Oxford, New York, pp. 606.

Coffel, E., Horton, R., 2015. Climate change and the impact of extreme temperatures on aviation. Weather, Clim., Soc. 7 (1), 94–102.

Comair, 2017. Intergrated Annual Report. Comair Limited, Johannesburg. 〈http://www.comair.co.za/Media/Comair/files/2017/comair-annual-report-2017-final.pdf〉.

Dessens, O., Köhler, M.O., Rogers, H.L., Jones, R.L., Pyle, J.A., 2014. Aviation and climate change. Transp. Policy 34, 14–20.

Directorate of Civil Aviation, 2016. Namibia Action Plan for CO_2 Emissions Reduction in International Aviation. Directorate of Civil Aviation/ ICAO, Windoek.

Dube, K., Nhamo, G., 2018a. Climate change and potential impacts on tourism: evidence from the Zimbabwean side of the Victoria Falls. Environ. Dev. Sustain. 1–17.

Dube, K., Nhamo, G., 2018b. Climate variability, change and potential impacts on tourism: evidence from the Zambian side of the Victoria falls. Environ. Sci. Policy 84, 113–123.

Dube, K., Mearns, K., Mini, S., Chapungu, L., 2018. Tourists knowledge and perceptions on the impact of climate change on tourism in Okavango Delta, Botswana. Afr. J. Hosp., Tour. Leis. 7 (4), 1–18.

Dubois, G., Ceron, J.P., 2006. Tourism/leisure greenhouse gas emissions forecasts for 2050: factors for change in France. J. Sustain. Tour. 14 (2), 172–191.

Government of Namibia, 2011. National Policy on Climate Change for Namibia. Government of the Republic of Namibia, Windhoek (Retrieved from). 〈http://www.met.gov.na/files/files/National%20Policy%20on%20Climat%20Change%20for%20Namibia%202011(1).pdf〉.

Higham, J., Cohen, S.A., Cavaliere, C.T., Reis, A., Finkler, W., 2016. Climate change, tourist air travel and radical emissions reduction. J. Clean. Prod. 111, 336–347.

IATA, 2008. Aviation and Climate Change UNFCC Climate Change Talks 2008. IATA. Retrieved from 〈https://www.icao.int/environmental-protection/Documents/STATEMENTS/AccraGhana_IataPresentation.pdf〉.

IATA, 2015. ICAO Carbon Emissions Calculator Methodology Version 8. International Civil Aviation Organization (Retrieved from). 〈https://www.icao.int/environmental-protection/CarbonOffset/Documents/Methodology%20ICAO%20Carbon%20Calculator_v8-2015.pdf〉.

IATA, 2017a. Airlines Financial Monitor. IATA, Montreal (Retrieved from). 〈http://www.iata.org/publications/economics/Reports/afm/Airlines-Financial-Monitor-Nov-17.pdf〉.

IATA, 2018. February 26). Aim for 1 Billion Passengers to Fly on Sustainable Fuel Flights by 2025. Retrieved March 4, 2018, from 〈http://www.iata.org/pressroom/pr/Pages/2018-02-26-01.aspx〉.

ICAO, 2017a. Challenges and Policy Making Challenges and Opportunities in Policy Making for Sustainable Fuels CAAF/2-WP/12. International Civil Aviation Organization, Mexico City.

ICAO, 2017b. Agenda Item 2: Financing and Assistance Programmes for Aviation Alternative Fuels. International Civil Aviation Organization, Mexico City.

ICAO, 2017d. Agenda Item 2: Financing and Assistance Programmes for Aviation Alternative Fuels CAAF/2-WP/27 Unique Airport Role to Advance Sustainable Aviation Fuel (SAF). International Civil Aviation Organization, Mexico City.

ICAO, 2017e. Agenda Item 4: Defining The ICAO Vision on Aviation Alternative Fuels and Future Objectives Industry Positions on the Proposed Icao Vision CAAF/2-WP/25. International Civil Aviation Organization, Mexico City.

Kantenbacher, J., Hanna, P., Cohen, S., Miller, G., Scarles, C., 2018. Public attitudes about climate policy options for aviation. Environ. Sci. Policy 81, 46–53.

Kenya Civil Aviation Authority- (KCAA), 2015. Kenya's Action Plan for the Reduction of CO_2 Gas Emissions in Aviation Sector. Kenya Civil Aviation Authority, Nairobi.

Law, A., Lacy, T., Lipman, G., Jiang, M., 2015. Transitioning to a green economy: the case of tourism in Bali, Indonesia. J. Clean. Prod. 295–305.

Njoya, E.T., 2016. Africa's single aviation market: the progress so far. J. Transp. Geogr. 50, 4–11.

Peeters, P., Gossling, S., Becken, S., 2006. Innovation towards tourism sustainability: climate change and aviation. Int. J. Innov. Sustain. Dev. 1 (3), 184–200.

Peeters, P., Higham, J., Kutzner, D., Cohen, S., Gössling, S., 2016. Are technology myths stalling aviation climate policy? Transp. Res. Part D Transp. Environ. 44, 30–42. https://doi.org/10.1016/j.trd.2016.02.004.

QAS, 2016. Carbon Offset Standards - Approval Procedures: Carbon Offsets 11/10/2016. Quality Assurance Standard Ltd. (Retrieved from). 〈https://qascarbonneutral.com/carbon-offset-standards/〉.

SA Express, 2016. Annual Report. SA Express. Retrieved from 〈http://www.flyexpress.aero/sites/default/files/SA%20Express%20Annual%20Report%20Final%202017_0.pdf〉.

SAA, 2016. Intergrated Annual Report for the Year Ended 2016. South African Airways, Johannesburg.

Schäfer, A.W., Waitz, I.A., 2014. Air transportation and the environment. Transp. Policy 34, 1–4.

Scott, D., Hall, C.M., Gössling, S., 2016a. A review of the IPCC Fifth assessment and implications for tourism sector climate resilience and decarbonization. J. Sustain. Tour. 24 (1), 8–30.

Scott, D., Hall, C., Gössling, S., 2016b. A report on the Paris climate change agreement and its implications for tourism: why we will always have Paris. J. Sustain. Tour. 24 (1), 8–30.

Storer, L.N., Williams, P.D., Joshi, M.M., 2017. Global response of clear-air turbulence to climate change. Geophys. Res. Lett. 44 (19), 9976–9984.

Williams, P., 2017. Modelling climate impacts on the aviation sector. In: Proceedings of the EGU General Assembly Conference Abstracts. 19, 3561.

WRI, 2004. The Greenhouse Gas Protocol a Corporate Accounting and Reporting Standard Revised Edition. World Business Council for Sustainable Development and World Resources Institute, Washington, DC. 〈http://pdf.wri.org/ghg_protocol_2004.pdf〉.